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The waterbirds of Parc National du Banc d'Arguin

Oudman, Thomas; Schekkerman, Hans; Kidee, Ahmadou; Roomen, Marc van; Tentij, Manon; Piersma, Theunis

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**The waterbirds of
PARC NATIONAL DU BANC D'ARGUIN**

**Evaluation of all complete winter counts,
Workshop proceedings,
and a future perspective**



20 April 2017

This report is written by: Thomas Oudman,
Global Flyway Network
Thomas.Oudman@gmail.com

In collaboration with: Hans Schekkerman and Marc van Roomen,
SOVON, Wetlands International, Birdlife International
Theunis Piersma,
NIOZ Royal Netherlands Institute for Sea Research
Ahmadou Kidee,
Observatoire du Parc National du Banc d'Arguin

Financed by: Programme Towards a Rich Wadden Sea
Contact: Manon Tentij

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Cover photo: Counting the birds on Niroumi, 28 January 2017. © Rob Buiter

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Group photo during the second workshop day (photo by Kidee Amadou)

SUMMARY

This is the report of an initiative to evaluate the results and methodology of all shorebird counts of the Banc d'Arguin in Mauritania. This was done by means of a workshop with all participants of the 2017 count expedition and a selection of researchers in the area, and an analysis of the 2017 census in the perspective of previous censuses. The goals of this initiative were (a) to gain more knowledge on the (causes of) temporal dynamics in the shorebird numbers at Banc d'Arguin, (b) to discuss the optimal design for future shorebird monitoring of the Banc d'Arguin, and (c) to improve the collaboration between all involved parties.

Total bird numbers have been declining since the first complete census in 1980 (2,384,000 birds) with 1,725,000 birds counted in the 2017 census, a slightly higher total estimate than the previous census in 2014 (1,459,000 birds). All seven total censuses combined showed a significant temporal linear trend for six species (all negative, except for one). For all other species, the data proved insufficient to determine temporal trends on the species level. An ordination analysis of all species per section suggests that species dependent on the intertidal mudflats decline more than species depending on the sublittoral and outer sea. Trends in population growth rates confirm this pattern.

Discussions during and after the workshop led to a list of recommendations for future monitoring. To determine population trends, a complete count should be undertaken more frequently, by a trained Mauritanian team. Besides more data, this will lead to more experience and a better census. This is a preferred scenario, but it will take considerable investments, particularly in the installation of a permanent, skilled and motivated team of observers. Senior bird counters, trend analysis professionals, and a local guide should be involved to train this team. A course in count data analysis should be organised in the Netherlands, and frequent training sessions should be organized in Mauritania, independent of the actual counts.

INTRODUCTION

Parc National du Banc d'Arguin (PNBA) in Mauritania contains about 500 km² of intertidal mudflats, and harbours more wintering shorebirds than any other place along the East Atlantic Flyway (Delany *et al.* 2009). Many of the migratory birds that visit the Wadden Sea in spring and autumn depend on this sole nature reserve for most of their lives. Because Banc d'Arguin is a vital part for the survival of these shorebirds, but is also threatened by various human activities, the necessity to monitor (changes in) bird numbers there is not a national issue, but of global importance. However, remarkably little is known about the dynamics of bird populations in Banc d'Arguin.

The first bird count was organized in 1973 by an English expedition, but did not cover the complete Banc d'Arguin and was in autumn (Knight & Dick 1975). A second French expedition in 1979 was more successful (Trotignon *et al.* 1980), but doubts have been raised whether this count did cover the complete Banc d'Arguin, or whether part of the numbers were estimates based on a later count. The next complete count was realized in January 1980 (Altenburg *et al.* 1982) and since then, 5 complete winter counts have been performed: in 1997 (Zwarts *et al.* 1998), 2000 (Hagemeijer *et al.* 2004), 2001 (Smit *et al.* unpublished), 2006 (Diagana & Dodman 2006) and 2014 (van Roomen *et al.* 2015). Several counts have been made between 1990 and 1994 that together cover all areas (Gowthorpe *et al.* 1996), but since the distribution may shift considerably even between tides, these counts are not considered to provide an accurate estimate. The 2014 count was part of an initiative to count all shorebirds along the East Atlantic Flyway at once, the result of a collaboration between the Wadden Sea Flyway Initiative, Wetlands International and BirdLife International (van Roomen *et al.* 2015). Now, three years later in January 2017, this effort has been repeated. The amount of data that is now available begs for an in-depth analysis of the changes in bird numbers in the Banc d'Arguin since 1980. In addition to the total counts, counts of a subset of regions in Banc

d'Arguin have been performed on an annual basis since January 2009 by PNBA staff. Also, the NIOZ Royal Netherlands Institute for Sea Research performed annual winter counts of the Iwik region since December 2003. These are included in the analysis, allowing some inference in the accuracy of the counts, and the potential to reduce monitoring effort by counting only a subset of the total area. Such analysis may also provide some perspective on the required frequency of future counts to allow inference. In addition, the analysis may lead to new ideas on potential ecological drivers of these changes, and/or ways to include these drivers into future monitoring efforts.

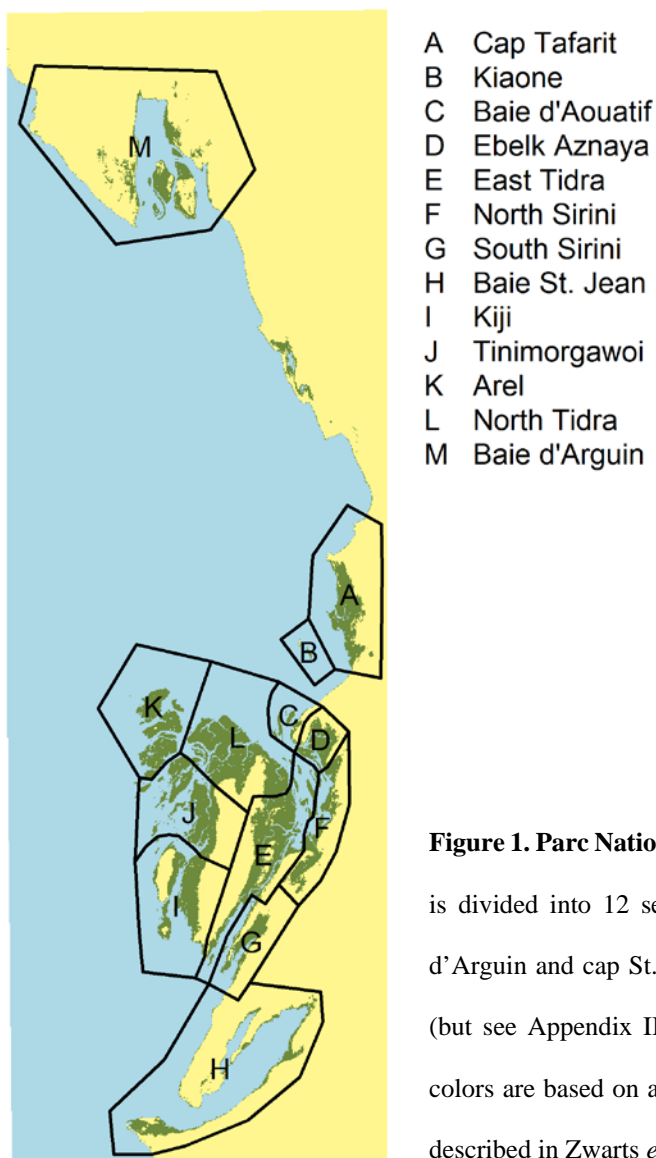


Figure 1. Parc National du Banc d'Arguin (PNBA). Banc d'Arguin is divided into 12 sections (A to L). Section M, comprising Baie d'Arguin and cap St. Anne, is not part of the analysis in this report (but see Appendix II). The intertidal area is shown in green. Map colors are based on a Landsat 5 satellite image. Sections A-L are as described in Zwarts *et al.* (1998).

The analyses were performed between January and March 2017. A workshop was organized at the PNBA Scientific Station in Iwik at the start and end of the count expedition to discuss the count methods, and the necessity and organization of future counts. This report provides a summary of the analyses, as well as a brief summary of the proceedings and conclusions of this workshop. In response to an explicit question by the PNBA staff, the last section of this report outlines a vision on future collaboration between the internationally involved parties, aiming to realize a solid framework for a successful permanent shorebird monitoring program in and by PNBA.

METHODS

Seven complete winter counts of the Banc d'Arguin were used for analysis, all performed in January/February: 1980, 1997, 2000, 2001, 2006, 2014 and 2017. The counts of 1997, 2000, 2006, 2014 and 2017 also included part or all of the Baie d'Arguin, a bay situated 70 km north of Banc d'Arguin. This area always harboured less than 5% of the numbers at Banc d'Arguin, and this area is not included in the analysis. The numbers in Baie d'Arguin can be found in the maps in Appendix II. Because doubts have been raised on the completeness of the 1979, and to avoid potentially false confidence on the numbers in those days because the 1979 and 1980 showed the same trend, it was not included in the current analysis. We stress that the 1979 count is not necessarily inaccurate, but further communication with the observers is necessary to confirm their completeness.

The areas were clumped into different 12 sections (Fig. 1; Zwarts *et al.* 1998). In the 2006 count, several sections were only partly covered, because the canal between Tidra and the mainland (see Fig. 1) was not visited. Linear regressions were performed of the total counts of the totals of the seven complete counts, for each of the 32 common shorebird species. A small part of the counts in 2017 contained exceptionally high numbers of some species and were checked with the observers. In some cases, the number was corrected by interpolation with other areas in the same year and with the same area in other years. This procedure affected 8% of the total number of waterbirds, and between 3% and 25% (mean 8%) of the totals by species. The dependency that this causes between data points, results in a lower accuracy of the statistical analysis, but we decided that this would be less problematic than assuming obviously erroneous numbers to be correct.

The variation of bird numbers and species composition between locations and years was studied by non-parametric multidimensional scaling (NMDS). 2006 was omitted from this analysis, because not all sections were

counted. The effect of different ecological variables on population growth rate were tested by comparing the explanatory power (AICc) of a series of linear models, using each of the common bird species as one sample. The tested variables included breeding strategy (migrant or resident), habitat (sea or intertidal), use of the Wadden Sea (yes or no), breeding in Siberia (yes or no), diet (one of five categories: fish, molluscs, crustaceans, worms, algae or generalist). Per-capita population growth rate (slope of the linear regression of population size over time, divided by the median population size) was used as response variable.

The area subset in which annual counts since 2009 have been performed by the PNBA staff consists of Arel (K), the islands of Nair and Niroumi (part of L), Ebelk Aznaya (C), Baie d'Atouatif (D) and Baie Saint Jean (H) (see Fig. 1). We compared the mean totals and the coefficients of variation per species between these subcounts and the total counts. We also determined the Pearson's correlation coefficient of the summed counts of those regions in years when total counts were performed, with the totals counts of all regions in those same years. The yearly counts of two sections (Baie d'Aouatif and Ebelk Aznaya, hereafter collectively called the Iwik region) since December 2003 (Theunis Piersma *et al.* unpublished data) were inspected for linear trends and compared to the trends across the Banc d'Arguin per species. These counts were compared to the other counts of the same region since 2009 (as part of the total counts or the sub counts) to assess counting accuracy.

We combined Western Reef Heron and Little Egret in the analysis, because the data implied that those were not distinguished properly in each count. Also all large falcon species (Barbary, Saker, Lanner and Peregrine Falcon) were combined for analysis.

RESULTS

Total counts per species

Since the 1980 count (2.38 million birds), the total number of birds has been decreasing (Fig. 2, $F_{1,5} = 10.6$, $R^2 = 0.61$, $p = 0.02$). Six species show significant trends over time, five of which are negative (Long-tailed Cormorant, Marsh Harrier, Red Knot, Eurasian Curlew and Bar-tailed Godwit, see Appendix II). Only the White Pelican shows a positive trend ($F_{1,5} = 6.8$, $R^2 = 0.49$, $p = 0.048$, see Appendix II). It must be stressed that the uncertainty is higher than it may appear, because the risk of a type I error (a significant result where actually no trend exists) increases with the number of statistical tests performed. When using a Bonferroni correction of

the significance level to reduce this error ($\alpha = 0.05/32 = 0.0016$), none of the species trends over time is significant.

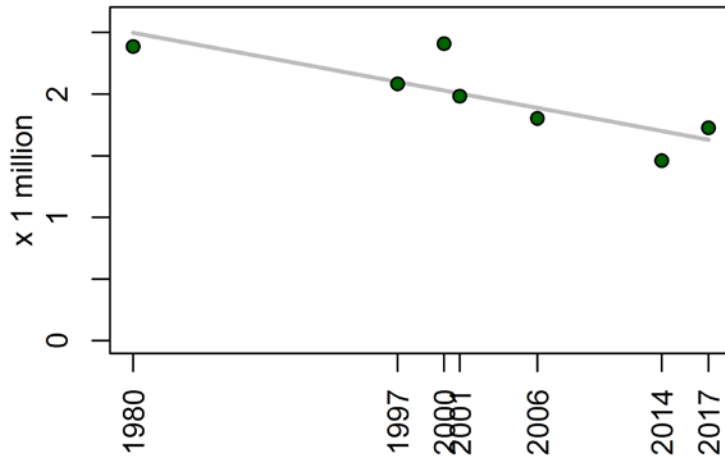


Figure 2. All complete counts of Banc d'Arguin. Baie d'Arguin is not included. The count in 2006 did not include the east part of Tidra and Sirini (see Fig. 1). All counts were performed in January and/or early February.

Partial Banc d'Arguin counts

The results of the partial shorebird counts of 2009 to 2013, 2015 and 2016 are shown in graphs in Appendix III, including the numbers for the same regions in the total counts. Variation between the counts was high for all species; the standard deviation was more than half of the mean in 27 of the 32 common species (see also Appendix VI). Three species showed a significant trend (but not when correcting for the number of statistical tests with a Bonferroni correction), all negative. These species, Oystercatcher, Slender-billed Gull and the small herons, are all different than those species showing a significant trend in the total counts. This difference implies that the observed trends must be interpreted with caution.

To check whether the sub count is indicative of total population size at Banc d'Arguin, we compared trends in the total counts with trends in the region subset. For most species, this subset shows much more variation than the total area counts. The average coefficient of variation (standard deviation divided by the mean) in the total counts is 0.47, whereas in all counts of the area subset, it is 0.85. It appears that this is partly due to less accuracy during the partial counts, because in these years, the coefficient of variation is higher (0.77) than in the

years with total counts (0.60). But this was not the only reason: in the years that a total count was performed, the number of birds in the subarea correlated significantly with the total count in only 16 species (Long-tailed Cormorant, Great Cormorant, Small Herons, Flamingo, Pelican, Turnstone, Curlew, Whimbrel, Bar-tailed Godwit, Dunlin, Curlew Sandpiper, Kentish Plover, Greenshank, Redshank, Caspian Tern and Little Tern). For four of these species, this is because a high percentage of the total population is commonly found in the counted sub regions (Long-tailed Cormorant 70%, Great Cormorant 70%, Pelican 60%, Small Herons 50% and Little Terns 50%). This percentage is lower in the other 11 species, and the correlation must be attributed to a correlation in population dynamics between the different regions. The average Pearson coefficient per species was 0.66.

Adding other regions to the sub-count would increase the significance of the correlations, but not greatly. Including Tinimorgawoi in the sub-count (the section with the most birds) would improve the correlation with the total count, but still 12 of the common species show no significant correlation, including Spoonbill, Red Knot, Dunlin and Oystercatcher. Based on a sample size of 7, it is impossible to show which areas correlate best for these species.

NIOZ Iwik counts

The annual NIOZ counts of the Iwik region (sections C and D in Fig. 1) show a different pattern than the total counts. Nine species show significant trends, giving quite a different image from the total counts. Three species show positive changes (Grey Heron, Greenshank and Whimbrel), and six negative (Marsh Harrier, Osprey, Oystercatcher, Curlew Sandpiper, Red Knot and Bar-tailed Godwit) (see Appendix II).

We compared the NIOZ Iwik counts with the other counts of the same region in the same winter seasons (see graphs in Appendix II). On average, the difference between the counts

was 60% of the largest of the two counts. The less conspicuous species showed higher mean differences (e.g., falcons, 89% and Curlew Sandpiper, 76%) than the obvious species (e.g. Greater Flamingo 36%, Grey Heron 33%). The terns also showed a high difference (70% to 100%). The significant patterns that were observed in the NIOZ counts, are not present in the data of the other Iwik counts. Also the average of the NIOZ counts per species and the average of the other counts per species differed greatly (48% of the largest value on average).

The observed per-capita population growth rates in the Iwik region (NIOZ counts) correlate significantly to the growth rates in the total Banc d'Arguin ($F_{1,30} = 6.9$, $R^2 = 0.16$, $p = 0.02$). However, the R^2 value is low, meaning that even though on average there is a correlation, there is much variation in accuracy (Fig. 3). Many different ecological reasons may

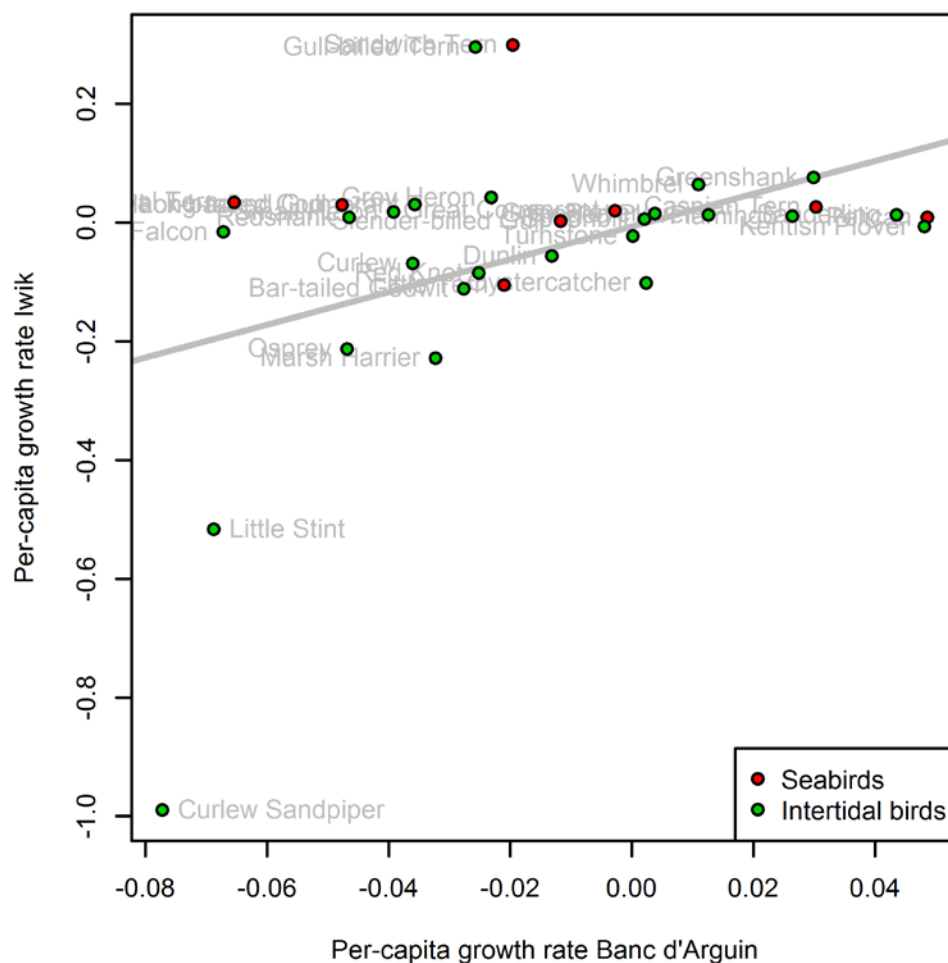


Figure 3. Linear trends in population growth in each species per individual per year compared between the total Banc d'Arguin (x-axis) and the Iwik region (y-axis). Each point is one species. The green points are

intertidal foraging species, the red points are sea foragers. The two rates show a positive but not very strong linear relation ($F_{1,30} = 6.9$, $R^2 = 0.16$, $p = 0.02$, grey line). BdA growth rates are estimated between 2000 and 2017, and Iwik growth rates between 2003 and 2017. See Appendix VI for species-specific rates that are unreadable in this graph.

underlie this variation. Some species may show a preference for the Iwik region and concentrate there when the population declines (e.g. Long-tailed Cormorant). Others may profit from increased prey densities outside the Iwik region and move out (e.g. Oystercatcher). Yet others may decline equally in all regions due to changes that affect all regions equally or lie outside PNBA altogether (perhaps Red Knots). This stresses the importance of more frequent counts in the total region. This is necessary to distinguish variation due to counting error from actual variation in bird numbers, and to distinguish local from general trends.

Analysis of species composition

If the ecological reasons for change are different between species, then ecologically similar species may show similar trends. This may provide clues on the ecological variables that underlie the observed trends. We performed an ordination analysis to determine which species show similar temporal and spatial dynamics. The results implied that the bird species composition at high tide changed over a spatial gradient moving from land to sea (NMDS axis 1, Fig. 4A), and also that seabirds and intertidal birds shown a strong segregation at high tide (NMDS axis 2, Fig. 4A). In the course of the years, the spatial gradient did not change, but a gradual shift seems to have taken place in the occurrence of diet groups, moving away from intertidal birds and towards species using subtidal and outer sea habitat (Fig. 4B). The latter could not be confirmed by a statistical analysis of the per-capita population growth rates, but the trends were in the same direction. Intertidal birds on average showed a decrease, whereas the sea foragers on average did not change (Fig. 5, for statistics see Appendix IV). Other

explanatory variables (diet, resident or migrant, Wadden Sea usage and whether birds breed in Siberia or not) did not affect the observed growth rates. Appendix V contains an ordination analysis in which we included 1979, showing that this count shows a species distribution pattern that is highly different from all other counts.

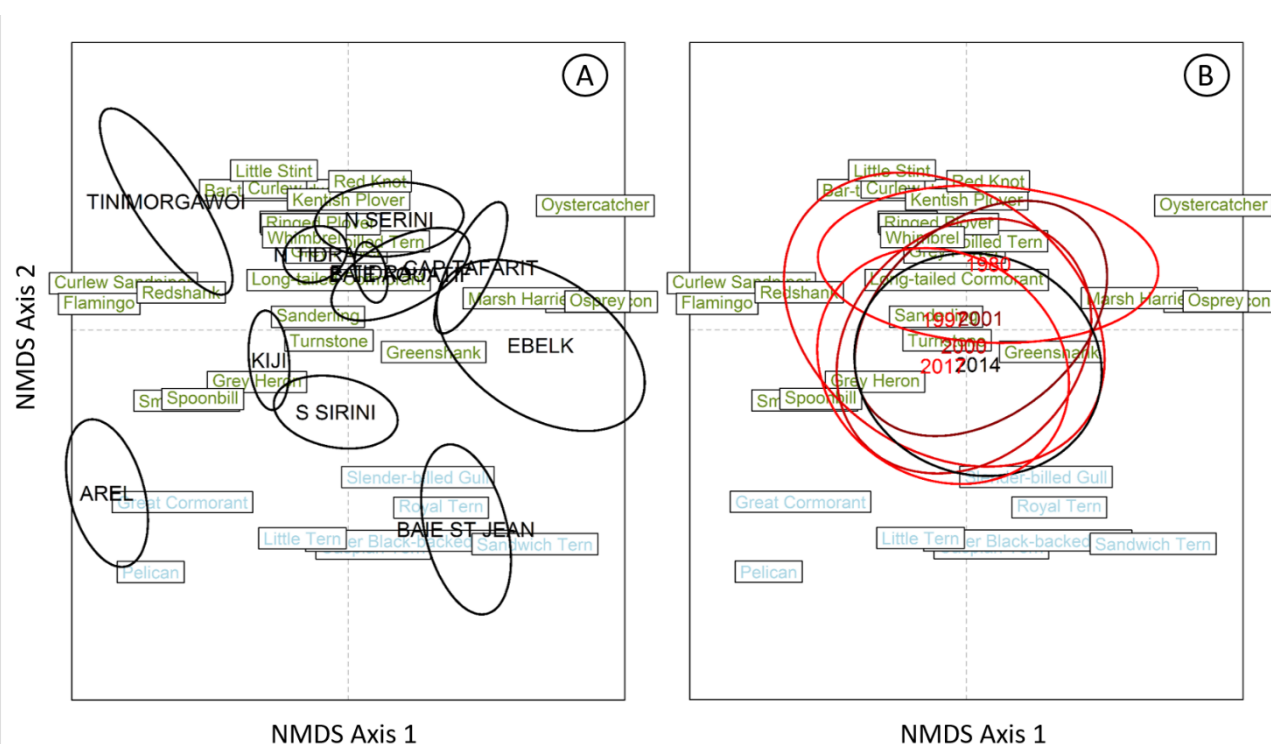


Figure 4. Ordination analysis of all species per section in all years. Species that are plotted close together tend to show the same spatial and temporal pattern of abundance. Seabirds are shown in blue, intertidal birds in green. Non-parametric scaling (NMDS) was used to enable comparison between different all bird species, greatly differing in population size and frequency distribution. (A) Mean positions of the eleven sections are shown in black, including their convex hull, enclosing the positions of the different sections in each year. (B) Mean positions of the different counts are plotted including the convex hull enclosing the position of the different years for each section, with darker colors for later years.

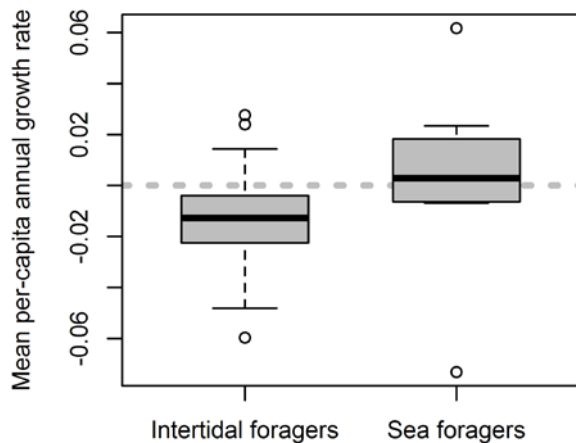


Figure 5. Per-capita population growth rates of intertidal species and subtidal or outer sea foraging species. Although not significant (see Appendix IV), population of intertidal species appear to decrease on average, whereas seagoing species do not.

WORKSHOP PROCEEDINGS

The first day of the workshop was on 23 January, on the second day of the counting expedition. The day consisted of a series of presentations at the research station of the PNBA, near the village of Iwik. Roughly, 70 people joined these presentations. The staff of the PNBA was present, including Director Maître Aly ould Mohamed Salem. Also all approximately 30 participants of the bird count were present, including staff members of Diawling National Parc, Nature Mauritanie, Djoudj National Bird Sanctuary (Senegal), and the University of Nouakchott. Dutch participants were present from Sovon, Vogelbescherming Nederland, Programme Towards a Rich Wadden Sea, the NIOZ Royal Netherlands Institute for Sea Research and the University of Groningen. Journalists were present from Mauritanian and Dutch National television, radio and newspapers. The program aimed at increasing the general knowledge of the ecological importance and the role of birds in the ecosystem of Banc d'Arguin. The day consisted of ten short presentations (see Appendix I for a full overview), covering all main aspects of the ecology of the Banc d'Arguin and an overview of previous counts, including the methodology and the counting results. These presentations were met with great enthusiasm, inspiring much discussion in the afternoon and in the days afterwards. By providing the general framework and showing the importance of more knowledge on bird numbers in the PNBA, this day contributed to the pleasant collaboration between the

Mauritanian and Dutch counterparts, and a strong motivation to carry out a successful count by all parties involved.

The second day of the workshop was organized on 1 February, after the counts. Before the start, the results of all counts were brought together in one file, and a quick-and-dirty analysis of the result was presented to the audience, comprised of approximately 50 people. Present were the Vice-Director of PNBA and the Minister of Environment and Sustainable Development, all participants of the count, and researchers from the Royal Netherlands Institute for Sea Research. Several suggestions for underlying causes of changes in bird numbers were proposed, as well as a number of aspects that could be improved in the methodology of future counting efforts.

CONCLUSIONS AND RECOMMENDATIONS

Temporal trends in total bird numbers

From the seven successful and complete counts of the Banc d'Arguin, it is clear that bird numbers are changing in Banc d'Arguin, but also that the frequency as well as the accuracy of the counts since 1980 has been too low to determine temporal trends with any confidence for most species. Nonetheless, the average per-capita population growth rates is significantly negative (mean -0.02, SE = 0.007, model 1 in Appendix IV), and shows a trend (not significant) towards lower growth rate for intertidal foraging species than for species foraging at sea (Fig. 5, see Appendix VI). More data is needed to validate this trend, and to determine whether species that migrate via the Wadden Sea and species that breed in Siberia indeed have lower population growth than other migrant species, as has been suggested (e.g. van Roomen *et al.* 2015). During the workshop, many different potential aspects arose that may influence the observed patterns.

Firstly, causes may lie within Banc d'Arguin. All species reliant on the intertidal are ultimately dependent on the seagrass dynamics, because that is the fundament of this complex ecosystem (van der Heide *et al.* 2012). Seagrass density is highly variable, entailing natural cycles (de Fouw *et al.* 2016) but potentially also human influences, for example via fisheries. Especially the current fisheries on Lusitanian Cownose Ray *Rhinoptera marginata* may change dynamics in the extent of the seagrass beds. The fact that one of the most strongly declining species, the Long-tailed Cormorant, is a resident, implies that problems may partly lie inside Banc d'Arguin, but that this strongly depends on the ecological niche of the species involved. Reasons for decline may relate to food abundance, e.g. fish abundance in the intertidal area in summer. Instead, migrant fish-eating species (e.g. Eurasian Spoonbills and especially White Pelicans) seem to increase, suggesting that fish abundance in winter, either at sea and in the intertidal, is sufficient and may even be increasing.

Secondly, causes may lie in other areas. Research on Red Knots and Bar-tailed Godwits has shown that climate change in the Arctic region has had a negative effect on survival, and is a likely cause of population declines (van Gils *et al.* 2016; Rakhimberdiev *et al.* in prep). Although causes of change are found outside the PNBA, yearly survival of Red Knots is expected to increase if the availability of *Dosinia isocardia* in the PNBA would increase. This bivalve species has been strongly declining in recent years, but reasons are unclear and may be part of the regular dynamics. Hence, although reasons for population declines may lie outside Banc d'Arguin, improved conditions inside the park may act as a buffer for the degradation of other areas, and safe populations. In addition, even resident species may be affected by changes elsewhere. It was proposed that improving conditions at other nature reserves such as the Djoudj in Senegal may induce a decrease in the use of Banc d'Arguin e.g. by Greater Flamingos.

Monitoring other ecological variables to infer the causes of bird population changes

Currently, the bird count data is not sufficient to infer underlying causes of specific population changes. Efforts on improving the accuracy and frequency of the counts will contribute to point out potential underlying causes. For example, it is expected that the difference between intertidal and subtidal/outer sea foragers becomes significant, and also other patterns may appear. These patterns should be the basis for efforts to measure ecological circumstances such as prey availability, and annual/seasonal changes therein.

Unfortunately, not much data exists on any ecological variables before the 2000s, when NIOZ increased its presence at the Iwik research station. The only consistent dataset that could be used to infer dynamics before 2000, is by the use of satellite images. Good images during low tide are available for each winter from 1999 onwards (Landsat 5, 7 and 8). Before, good images are available for the winters of 1973 (Landsat 1), 1979 (Landsat 3), 1985 and 1987 (Landsat 5). Only two area-wide benthos sampling programs have been performed. The first one, in the 1980s by Wim Wolff, was extensive and covered multiple years (e.g. Wolff *et al.* 1993), but the raw data is not yet digitized. The other one was performed in 2007, and covered 56 stations throughout the Banc d'Arguin (Folmer *et al.* 2012, Erik Jansen, Master Thesis), which is a very low sample size given the high spatial heterogeneity of those mudflats. NIOZ efforts since the 2000s have focused on a small subarea comprised of section C and D (e.g. van Gils *et al.* 2013). Future efforts on area wide benthos monitoring could be used to infer food availability at least for bivalve and worm eaters (see e.g. van Gils *et al.* 2013), but the effort will be considerable, and will be too much work to combine it with a proper bird count. Independent expeditions will need to be organized.

Sources of uncertainty

It is commonly known that high tide counts come with large uncertainty (e.g. Rappoldt, Kersten & Smit 1985). For the Banc d'Arguin specifically, doubt have been raised about the estimated population size of Bar-tailed Godwits (Spaans *et al.* 2011). They calculate population size of *taymirensis* Godwits by estimating the proportion of colourringed birds in flocks. They find a significantly lower number than estimated from the here presented counts, and suggest that either the counts over-estimate the number of birds, or the population is in serious decline. The results shown here suggest that at least to some extent, the latter is the case. However, current counts in the Banc d'Arguin (little over 200,000) are similar to what Spaans *et al.* estimate for the total population (240,000), a significant part of which winters in Guinee Bissau and other places (van Roomen *et al.* 2015). This implies that high tide counts may overestimate the actual number of Bar-tailed Godwits. We shortly discuss the potential sources of error in the high tide counts.

Firstly, the estimated error in the count of large roosting bird flocks, even by experienced workers, is known to be high (Rappoldt, Kersten & Smit 1985 found an average error of 37% for flocks of sitting shorebirds). This error is expected to cancel out when counts consist of many counts of small flocks, but flocks in Banc d'Arguin can be very large, and counts of the main species are dominated by assessments of a few very large flocks. In 2006, almost 1.1 million birds (more than half of the total count) were counted on one single islet, Tinimorgawoi.

Secondly, roosting waders at Banc d'Arguin often occur in mixed flocks. This leads to a potential misidentification of birds, and likely an underestimation of less conspicuous and less common species that occur among common species (e.g. Curlew Sandpipers and Little Stints among flocks of Dunlins), and a large influence of observer experience on the results. This error

may be reduced by using a consistent method of counting, and by regular training of the observers.

Thirdly, some species, mainly the fish-eating ones, may not be roosting during the high tide. Their population size will be underestimated when part of the population is foraging far from the coast during the count. Which proportion is away, can be influenced by many different factors, but especially temporal and spatial patterns in the availability of prey.

Finally, flocks may be counted double (or not at all) if different areas used by the same birds are not counted at the same time. This source of error is potentially high in Banc d'Arguin because ecological as well as geographical knowledge of the area is limited, especially in rarely visited and inaccessible areas such as the region west of Tidra. Perhaps not coincidentally, these are just the regions where bird numbers are highest. Another source of double counts is when borders are not clear. Especially with Flamingos, this may be a problem; if they stand far away in shallow water, it may be difficult to assess in which counting area they actually stand.

The relevance of counting a subset of counting sections each year

For the sub-count to be a valuable indicator, the minimum requirement is that it shows a correlation with total abundances. In most of the common species a positive correlation appears to exist, but the correlation is significant only in 16 out of the 32 common species. The fish eating species show a higher correlation, because their main areas are better represented in the sub count. Unfortunately, there is not enough data to say with which regions actually show the best correlation. Testing the effectiveness by comparing it with the total counts, is an indirect test, and the total count contains a high level of uncertainty itself.

The large average difference between the two annual winter counts of the Iwik region (60% on average) shows that a large part of the observed variation must be attributed to error in the estimates, although part of it will be explained by actual fluctuations in numbers, as the

counts were not on the same day. The annual variation per species is lower in the NIOZ counts, which may be the effect of a consistent counting method and group of observers.

The fact that even the averages of all years differ markedly between the NIOZ counts and the other counts of the Iwik region, shows the necessity of improving the counting accuracy. More effort needs to be invested in training and consistent methods. Given the already low explanatory power of the total count, a count of only a subset of the areas currently provides very little power to identify changes in shorebird population sizes in Banc d'Arguin.

Recommendations to improve the monitoring quality

More frequent complete counts of Banc d'Arguin by a permanent team of observers is necessary to attain the sample size that is necessary for statistical analysis, because the error in single count estimates is very high. It is also important to monitor the underlying ecological variables such as seagrass condition and benthos dynamics, but this should not come at a cost to the bird counts. The first step is to invest in more frequent and complete counts. Simultaneously, more frequent counts will greatly improve the accuracy of the counts. Experiences from the previous count will be fresh in mind, both on the tide, the terrain and on bird behavior. This enables the optimization of the planning of the count, and the division of count sections over the different available days. With a consistent team, the methodology can be better standardized. This does not only apply to the count itself, but also to the cleaning of the data afterwards. Many errors can be avoided by a good and critical check of the data by all observers together, right after return from the field. This is essential to any proper bird count, be it by professionals or amateurs. Finally, a frequent count would also mean that all regions of the Banc d'Arguin ecosystem will be visited and inspected on a regular basis, which will greatly improve the capacity to detect large changes quickly.

A frequent total count will best be organized locally, because it will greatly reduce travel costs and time investments by the observers. The current expedition has shown that it should be possible to organize a team of 6 - 8 motivated Mauritanian observers that perhaps even could perform a yearly count once more experienced, and assisted by a group of less experienced bird counters. It is important that this team and the financing parties will make a long-term commitment, because it will require long-term investments in training. To further ensure long-term commitment, it is important that the participants are young and have fixed positions at one of the involved institutes, such as PNBA, Nature Mauritanie and/or the University of Nouakchott. SOVON, the organization that since 1995 organizes complete counts of the Dutch Wadden Sea 5 times a year, could invite this team to the Wadden Sea for a masterclass, focusing not only on counting itself but also the logistic aspects and database management. Similarly, the NIOZ could organize a masterclass on the analysis of the data. For a successful masterclass in the Netherlands, the team should ideally include young and English-speaking members. Training sessions should take place in PNBA, and independent of the counts themselves.

More detailed and focused research on may reveal underlying causes of decline. Analysis of satellite images can reveal historical dynamics in the dynamics of intertidal seagrass. Quantifying seagrass abundance per section (Fig. 1) and comparing it to population distributions across these regions (see Appendix II) may reveal whether different bird species abundances correlate to changes in seagrass dynamics.

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